LEARNING 9 EXPERIENCE

Emerging Diseases, Emerging Problems

PROLOGUE Medical science has made tremendous advances against the scourges of infectious disease. Early in the twentieth century, predictions were commonly made that infectious diseases would soon be relegated to science history as public health measures and technology seemed to eliminate the problems globally.

These predictions, however, have not come true. Infectious diseases remain the major cause of death worldwide and a leading cause of illness and death in the United States. Since the early 1970s, appearances of diseases with symptoms never before described and diseases once thought vanquished have been routinely reported worldwide. Newly identified pathogens and their associated diseases have included the human immunodeficiency virus (HIV) which leads to AIDS, Legionnaires' Disease, hantavirus, Lyme Disease, hepatitis C virus, and toxic shock syndrome. Reemerging diseases (that is, diseases once thought under control but making a comeback on the public health scene) include tuberculosis, malaria, cholera, pneumococcal diseases, salmonellosis, and staphylococcal infections.

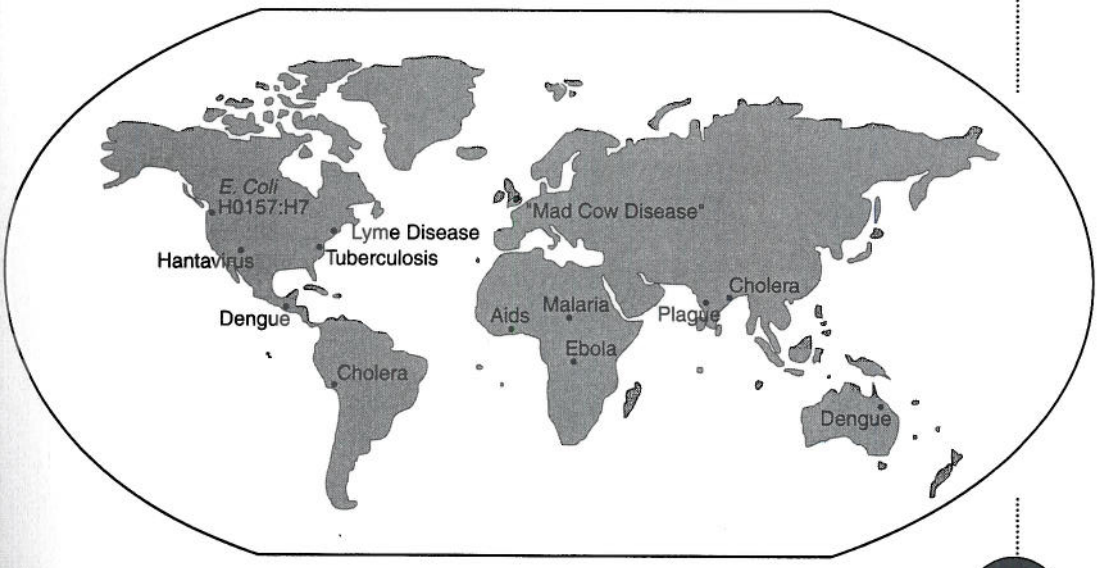

Figure 9.1
Examples of outbreaks of emerging diseases worldwide

What are the origins of so-called new diseases that are reported in the news with increasing regularity? Are they really new diseases caused by new pathogens, or does a new set of circumstances enable a disease to appear in the population? Why are some diseases, once thought to have been conquered by modern medicine, reappearing in new, more virulent forms?

In this learning experience, you will begin a long-term research project in which you will investigate, in depth, the circumstances, biological and social, which can result in the emergence or reemergence of a disease.

READING

They're Everywhere

Some of the diseases that have emerged and the social changes that enabled them to spread to new places are described below.

- AIDS is thought to have originated when a virus was trasmitted from African wild monkeys to humans by an as yet unknown mode of transmission.
- Lyme Disease is transferred from deer ticks to humans as the result of increased human contact with deer in suburban areas.
- Dengue fever was unknown in the United States until the virus's mosquito vector was transported accidentally from Asia in shiploads of tires filled with rainwater.
- In the 1960s, the Peace Corps set up pumps in many villages in Africa to bring water. These pumps also brought malaria by creating new breeding grounds (puddles of standing water) for the mosquito vector of the parasite.
- The building of the Aswan Dam in Egypt brought water for agriculture, but also brought epidemics of yellow fever, a viral disease, and schistosomiasis, a parasitic disease.
- Outbreaks of cholera continue to occur as people crowd into cities to find jobs or into refugee encampments to escape the ravages of war.

A change in either the virus itself or the vector which carries it may result in the emergence of a new disease or the reemergence of a known one such as the following examples.

- Canine parvovirus, which appeared in dogs in 1978 and causes life-threatening distemper, seems to have originated from a mutation in the feline parvovirus that enabled the virus to infect a new host.

- When first identified hantavirus caused kidney infections. A change in a viral protein appears to have altered the tissue specificity of the virus, resulting in a severe, often deadly, lung disease.
- Tuberculosis, gonorrhea, and staphylococcal infections, once considered almost vanquished, have increased because of the misuse of antibiotics and the development of drug-resistant strains of the bacteria.
- Misuse of insecticides also has resulted in the resurgence of disease; the development of insecticide resistance in the mosquito has resulted in the reappearance of malaria, once almost nonexistent in regions where insecticides were used.

Recent discoveries have begun to implicate infectious agents as the cause of diseases previously considered noninfectious, including:

- Bacteria of the species *Helicobacter pylori* have been well established as the causative agent of peptic ulcer disease.
- Human papillomavirus, which can be transmitted during sexual activity, is associated with cervical cancer in women.
- Hepatitis C virus is now considered the leading cause of chronic liver disease, cirrhosis of the liver, and has been associated with liver cancer.
- The sexually transmitted *Chlamydia trachomatis* bacteria have long been implicated in infertility, and another strain of *Chlamydia* has recently been associated with coronary artery disease.
- The infection in utero of a fetus by *Toxoplasma gondii*, a parasite, has been shown to cause congenital mental retardation.

Emerging Diseases

ACTIVITY

INTRODUCTION In this module, you are exploring the nature of infectious diseases and the agents which cause them. In this long-term research project, you will need to apply the concepts from the module in order to understand the factors involved in the emergence or reemergence of a disease. At the end of the module you will present the findings of your research to the rest of the class as a public health policy that you have developed for creating strategies to reduce the risk of future outbreaks of this disease.

In preparation for the final presentation, you will be working in groups of four. Each group will be responsible for developing expertise about an emerging infectious disease. At this point you may not have all the background to address some of the issues. Some of this background

will be acquired in the remainder of the module and some you will acquire through your own research.

► TASK

Work as a group, assigning responsibilities for efficiency. (However, all members of the group are responsible for knowing how to carry out each step and for knowing the information and group recommendations.)

1. Select the disease your group wishes to research, either from the list in the reading "Emerging and Reemerging Diseases" which begins on page 99 or another emerging or reemerging disease of your choice.
2. Gather resources on the epidemiology, environmental and social factors, and biological data of your diseases from the library, Internet, public health policy groups, local health professionals, and national organizations such as the Centers for Disease Control and Prevention (CDC) and the National Institutes of Allergies and Disease. When conducting research, look for information that will help you respond to the questions that follow.

- **EPIDEMIOLOGY**
  - When and where was this disease first recognized?
  - Why is this disease considered emerging or reemerging?
  - How many documented outbreaks have there been?
  - What are the mortality rates? (How many individuals have died?)
  - What are the morbidity rates? (How many individuals were made ill?)
  - What population has been affected by this disease?
  - What characteristics (habits, travel, work, relationships, gender, cultural practices, etc.) did this population share that may have contributed to the outbreak?
  - What methods were used to trace the outbreak?
  - Who has done the research? What is the story behind their research and investigation into the outbreak?

- **ENVIRONMENTAL AND SOCIAL FACTORS**
  - In what kind of environment did the pathogen first cause illness?
  - Describe the communities which have been affected. Did any social customs, economic factors, or political difficulties occur or change which might have provided the pathogen with a new host or might have facilitated the spread of the disease? If so, explain what happened and how these factors created an opportunity for the pathogen.
  - Did any changes occur in medical practices (such as changes in drug use, new procedures, loss of health care facilities, reduction in prevention programs)?

- Did any changes occur in the local or global environment (such as deforestation, reforestation, drought, famine, global warming) which might have caused new opportunities for the host/pathogen contact? If so, explain what happened and how these factors created an opportunity for the pathogen.

- **BIOLOGICAL DATA**
  - Describe the mode of transmission of the disease. How was this determined?
  - What is the nature (virus, bacteria, parasite) of the causative agent? How was this determined?
  - Describe what is known about the biology of the pathogen. Where in the host does it grow? What requirements does it have to maintain its own life functions? How does it affect the host's ability to maintain its life functions? Which biological functions in the host does the pathogen disrupt?
  - What characteristics of this pathogen enabled it to enter a new host?
  - What kind of immune response does this organism provoke in its host?
  - What are the symptoms it produces? What is the biological basis of these symptoms?
  - Is it related to other familiar or unfamiliar pathogens? Did any changes occur in the pathogen (such as changes in virulence, development of drug resistance, changes in tissue or host specificity) to cause this new or reemerging disease? If so, describe these changes and how they contributed to the appearance of this disease.

Because not everything is known or understood about these infectious agents yet, you may not find the answers to all of these questions. If this is the case for your disease, explain in your presentation that certain data is unavailable, or has not yet been ascertained by the experts. Be aware that information about diseases and their agents changes continually, and today's "facts" are sometimes tomorrow's fiction due to new findings and discoveries in research.

3. Develop a public health policy.

Once you have gathered your resources and information in the areas described above, you will be responsible for designing a public health policy which proposes strategies for reducing the risk of future outbreaks. This policy must consist of strategies that are realistic and take into account the context of local social conditions in which they are to be carried out, the living conditions, the economic status of the area, the political situation, and any changes which are occurring in the area. So, for example, do not propose a high-cost

solution to problems in a desperately poor developing nation. Do not try to change centuries-old social customs and habits. Do gain a perspective of the culture and economic situation in which this disease is occurring.

Your policy should include the following:

- a brief description of the disease; its epidemiology, the nature of the causative agent, the events which led to the outbreak in the area;
- strategies for reducing the occurrence of this disease (such as developing programs for education in behaviors to reduce risk, implementing changes in sanitation infrastructure, expanding health care and public health services, developing vaccines or drugs, and developing programs to determine risks involved in certain environmental development programs). Include an explanation of why these strategies would be effective.
- methods for identifying and containing future outbreaks should they occur (surveillance systems for the early detection, tracking and control of the disease).

4. Prepare your presentation.

The final presentation, which should last about 10 minutes, should include:

- appropriate information and background materials on your disease;
- a description of your public health policy, the rationale behind it, and an explanation of how it takes into account the specific social and economic conditions of the community in which the disease occurs.
- Visual aids which help facilitate your presentation.

The presentation will take place at the end of the module. At the close of each presentation, the teacher will ask follow-up questions, and then the class will discuss your public health policy proposal. Altogether, the presentation and follow-up discussion should take about 20 minutes.

5. Compare the emergence of different diseases.

As you listen to other presentations, take notes on the following:

- common themes that have been observed about emerging diseases;
- how the problem of infectious diseases should be addressed in making public policy;
- what strategies could be put in place for anticipating the rise of new diseases.

A discussion at the end of the presentations will address these questions.

EVALUATION

Your final presentation will serve as an assessment. The presentations will be evaluated by your teacher and fellow students on the following criteria:

- Have you gathered sufficient and appropriate information?
- Have you reached logical conclusions about your emerging or reemerging disease based on the information and ideas you have gathered?
- Does your presentation reflect insight and understanding of the reasons for emergence or reemergence of the disease?
- Does your public policy proposal demonstrate knowledge about local conditions at the site of the outbreak? A thoughtful and feasible response to those conditions? An understanding of the problems posed by the pathogen you have been studying?
- Is the presentation organized, clear, and effective? Does the presentation enable the audience to become engaged and interested in the topic?
- Are you able to respond concisely and clearly to questions from the audience?
- Does your presentation demonstrate that each member of your group has been involved in the process of researching the information, defining the policy, and preparing the presentation?

READING

Emerging and Reemerging Diseases

The following are some examples of diseases which have been classified by the CDC as emerging or reemerging infectious diseases; that is, diseases that have shown increased occurrence in humans within the past two decades. With your group read through the list and choose a disease which you would like to investigate. Alternatively, your group may select a disease of your own choosing but you must confirm that this disease is considered an emerging or reemerging disease.

ACQUIRED IMMUNE DEFICIENCY VIRUS (AIDS)

Caused by the Human Immunodeficiency Virus (HIV), AIDS was first recognized as a new and distinct clinical disease in 1981. Initially identified as a disease of homosexual men, AIDS has developed into an increasing threat to all populations. Transmitted by sexual contact or by

blood contact, it is estimated that more than 22 million persons are currently infected with the virus with 8,000 new infections occurring everyday. Early infection with HIV shows no detectable symptoms, but its site of infection (white blood cells of the immune system) leaves infected individuals susceptible to a variety of rare and not-so-rare diseases. Since no cure or treatment is presently available, death is the inevitable outcome of infection. Death is generally caused by one of the diseases rather than directly by HIV.

HEMORRHAGIC FEVER

In 1976, a terrifying disease made its appearance in Zaire. Caused by the Ebola virus, this disease is characterized by massive internal bleeding and kills nine out of ten individuals infected. The disease reappeared in Zaire in 1995. Epidemics of this disease have resulted from transmission by direct contact with infected individuals or laboratory monkeys. The most recent epidemic in Zaire was believed to be spread by the funeral practices of the people. Ebola virus spreads through the blood and replicates in many organs, causing extensive damage which results in bleeding, shock, and death. No specific cure or vaccine exists.

LYME DISEASE

First described as a disease during an outbreak in Lyme, Connecticut, in 1975, Lyme disease is caused by spirochete bacteria that are transmitted by a tick vector. The disease is becoming a major problem in many parts of the United States, particularly in suburban areas where deer and human populations are living in closer proximity. The symptoms of Lyme Disease include swelling around the infected area and flu-like symptoms which, left untreated, can develop into neurologic and cardiac problems.

HEMORRHAGIC COLITIS (FAST-FOOD SYNDROME)

In 1993, children in the state of Washington were coming down with bloody diarrhea (hemorrhagic colitis). Subsequent reports of this disease have appeared in Minnesota, Massachusetts, and other states. The causative agent has been identified as *Escherichia coli* 0157:H7. Infection has most commonly been linked to eating undercooked beef such as hamburgers. Initially associated with foods served in fast-food restaurants, contaminated beef has begun to appear in supermarkets. The bacteria can also be transmitted through poor hygiene practices.

TUBERCULOSIS

Tuberculosis, also known as consumption and the great white plague, was one of the leading causes of death prior to the introduction of antibiotics in the 1940s. Between 1953 and 1984, the number of new

cases of tuberculosis, which is caused by rod-shaped bacteria, dropped from 84,000 to 22,000. Public health workers foresaw the end of tuberculosis in the twenty-first century, but in 1985 the case rate began to increase at an alarming rate due to the appearance of multi-drug-resistant strains. Transmitted through droplets formed during coughing by infected individuals, the symptoms include fatigue, loss of weight and appetite, fever, and a persistent cough. If left untreated, death is common. A vaccine known as BCG confers some protection but is not readily available in the United States.

TOXIC-SHOCK-LIKE SYNDROME

Headlines such as "New Flesh-eating Bacteria Stalks Population" flashed across newspapers and tabloids in the early 1990s. Individuals who had suffered minor wounds or injuries were experiencing symptoms of severe invasive infections that were causing extensive damage to soft tissue and in many instances resulting in death. The infecting agent was identified as *Streptococcus pyogenes*, long known as the causative agent of a childhood disease, scarlet fever. Scarlet fever, which is characterized by a diffuse rash and fever, had been a common disease prior to the 1950s, when it virtually disappeared, most likely due to the use of penicillin to treat sore throats which are also caused by *S. pyogenes.* However, in recent times this pathogen appears to have returned with a vengeance, appearing first as a skin or wound infection and then developing into bloodstream infections sending the patient into shock.

MALARIA

Far from being a new disease, malaria has been known since antiquity. Caused by the parasitic protozoan *Plasmodium*, which is transported by a mosquito vector, malaria causes widespread disease and death in Africa and Asia. At various times in history, malaria was thought to be a conquered disease; eradication of the vector brought relief to the United States and many parts of Asia. But malaria is back. Misuse of antibiotics and insecticides has resulted in drug-resistant strains of the parasite and insecticide-resistant mosquitoes. Malaria is on the rise and the arsenal with which to combat it has diminished. Approximately 300 million of the world's people are afflicted with the disease, and each year between 1 to 1.5 million die, many of them children. Symptoms include fever, shivering, pain in the joints, and headache.

BOVINE SPONGIFORM ENCEPHALOPATHY ("MAD COW DISEASE")

Bovine Spongiform Encephalopathy (BSE) became a significant problem in Great Britain in the early 1990s when this neurological disease began affecting significant numbers of cattle. An alarm was sounded in

the mid-1990s when several young men and women in Great Britain died of a rare, particularly in young people, neurological disease which affects the brain and spinal cord, causing sponge-like lesions. As these symptoms resembled those found in cattle infected with BSE, the question was raised as to whether the infectious agent (a somewhat mysterious agent called a prion which appears to be made up entirely of protein) could be transmitted by ingesting contaminated beef. The possibility of such an epidemic raised a serious threat both to the health of beef-eating individuals and to the British economy, which is dependent on the export of beef.

READING

Behold the Conquering Pathogen

Despite all the technological and medical advances made in the twentieth century, today's physicians, policy-makers, and scientists sometimes find themselves in a position reminiscent of the one John Snow found himself in, back in 1854. In the last forty years, medical researchers and physicians have been confronted with unfamiliar, sometimes terrifying diseases.

In the following article, David Satcher, director of the CDC in Atlanta, describes some of the lessons and challenges that emerging and reemerging diseases present.

Excerpt from

Lessons and Challenges of Emerging and Reemerging Infectious Diseases

David Satcher, ASM News. *vol. 62, No. 2, 1996.*

In 1821....Americans had an average life span of well under 50 years, and the vast majority of deaths were due to infectious diseases. In the first half of the 19th century, problems such as malaria, yellow fever, and cholera were present even in the mid-Atlantic states, and respiratory diseases such as diphtheria, pneumonia, and rheumatic fever were the routine killers of children and adults. Even at the turn of this century, infectious diseases remained the leading cause of death, with tuberculosis leading the entire list in the United States.

Now that is no longer the case. Over the course of the 20th century we have made tremendous progress in our efforts to control infectious diseases. Perhaps the best-known accomplishment in this area is the eradication of smallpox, with the last case occurring in Somalia in 1977. Smallpox thus became the first disease in history to be completely eradicated from the world. As a result, millions of people around the planet will no longer needlessly suffer a painful

death and disability from this dreaded disease.

Following on the heels of the smallpox success, polio is well on its way to eradication. Over a period of only 40 years, we have gone from a situation in which millions of children were stricken with this terrible disease every year to the recent certification of the western hemisphere as free of polio.

Major advances have also occurred on a number of other fronts; the number of measles cases in the United States reached a historic low in 1994, and *Haemophilus influenzae* type B disease is rapidly fading as a leading cause of childhood meningitis and sepsis as a result of the introduction of conjugate vaccines in the late 1980s.

These spectacular successes have occurred for a number of reasons, including improvements in the standard of living (including basic sanitation and hygienic measures), the development and introduction of vaccines, and the development and introduction of antibiotics.

These successes have taught us some important lessons. First, combating disease requires a strong collaborative effort between the basic sciences, clinical medicines, and public health. Polio provides an example: basic scientists developed vaccines to protect against disease; clinicians diagnosed disease, cared for patients, and delivered vaccines; and public health implemented vaccination campaigns and monitored for the occurrence of cases. None of these entities can perform alone and expect success. The second lesson is that when we put our minds to it, we can achieve spectacular results in the area of infectious disease control and prevention.

Not so many years ago, many of the best scientific and public policy minds in the country were ready to close the book on infectious diseases. Essentially we were victims of the very successes that I just mentioned. These experts believed that our vaccines and antibiotics would solve all of our problems and we could easily control any new problem that arose. As events of recent years have shown, these pronouncements were premature.

In the 1990s, infectious diseases account for more than 50% of deaths throughout the world, and we are increasingly faced with new and reemerging disease challenges. Examples of these threats include the worldwide AIDS epidemic, which is now 15 years old and growing; the resurgence of tuberculosis in the late 1980s; the new hantavirus first detected in the southwestern United States in 1993; the 1994 epidemic of plague in India; diphtheria sweeping across the former Soviet Union; a new cholera strain in south Asia; and the frightening reemergence, for the first time since 1979, of Ebola virus last year [1995] in Zaire.

Virtually every year brings information on a newly recognized pathogen, such as the herpes virus responsible for Kaposi's sarcoma and the morbillivirus which killed horses and their trainer in Australia. Compounding the problem, our microbial foes have developed an amazing capacity to resist our control efforts, particularly through the development of drug resistance, and we are helping them by injudiciously prescribing and taking antibiotics. Probably more than anything else, emerging antibiotic resistance threatens to reverse many of the hard-fought gains made in the control of infectious diseases in the last century.

Why is this happening? There are many factors responsible for the resurgence of infectious diseases, including human behaviors, and demographic changes, technologic and industrial advances, changes in the environment, international commerce and travel, and a breakdown of public health control measures.

LESSONS FROM EMERGING AND REEMERGING DISEASES

We have learned and are learning several lessons from emerging and reemerging disease. First, we must never take for granted the adaptability of the

Continued on next page

microbial and parasitic coinhabitants of this planet with whom we compete for space and resources, including food. Just as we have the ability to create new weapons such as vaccines and antibiotics and pesticides, these coinhabitants have demonstrated the ability to develop new defenses, new pathways, and new armamentaria [inventory of resources] for survival and growth. We see it in the drug-resistant *Streptococcus pneumoniae* organisms or the enterococci. We see it in the drug-resistant malaria that is now ravaging parts of Africa. This ability to survive, to change, and to grow is a major force of our coinhabitants that we cannot afford to underestimate.

Second, just as human behavior, demographics, and lifestyles have been shown to be major factors in chronic disease epidemiology, it is increasingly clear that they are major factors in emerging and reemerging infectious disease. Examples include antimicrobial misuse and resistance, the role of sexual behavior in AIDS transmission, the role of cooking practices in *Escherichia coli* O157:H7 transmission, the role of funeral practices in the spread of Ebola virus in Africa, and the role of human-rodent interaction in many parts of the world in supporting diseases such as the plague in India or the hantavirus in the southwest.

The third lesson is that progress in modern technology and changes in ecology and land use often bring with them unintended and undesirable consequences. Examples include the invasion of the rain forest in South America and Africa and the appearance of new viruses such as Bolivian hemorrhagic fever virus, Guanarito virus, and Ebola virus and air handling systems, and the emergence of Legionnaires' disease.

The fourth lesson is that increasingly we live in a global community and public health, in order to be effective, must be global in nature and outlook. We are today less than 24 h [hours] away from almost any community in the world, and people who encounter an infectious disease agent in one part of the world today may be in a totally different part of the world tomorrow. We must remember that viruses, bacteria, and parasites do not need visas to cross borders and they even occasionally ride first class.

The last lesson is that prevention of infectious diseases makes economic sense in addition to medical sense. A dose of measles vaccine saves $17 [for each dollar spent on treatment] in health-care expenses. Once polio is eradicated, it is estimated that the global savings will be >$1.5 billion per year. And in the mid-1980s we estimated it would take about $40 million in federal expenditures to eradicate tuberculosis from the United States. Now we are spending over $100 million annually as a result of its resurgence and the emergence of multiresistant forms. As is true of most medical problems, prevention of infectious disease pays.

If we keep these lessons from emerging infections in mind, they will serve us well in years ahead as we attempt to be a healthier people in a healthier world through prevention.

All of this change has contributed to the rising threat of infectious disease to the health, well-being, and perhaps even survival of the human population. Surprising as this threat may be, perhaps it is not unexpected. Joshua Lederberg, winner of the Nobel prize in Medicine in 1958, made the following statement:

> *It is still not comprehended widely that AIDS is a natural, almost predictable, phenomenon. It is not going to be a unique event. Pandemics are not acts of God but are built into the ecological relations between virus [bacteria, parasite], animal species, and the human species, and we had better understand that or we will rue it".*
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> *Excerpted from J. Langone. "Emerging Viruses."* Discover Magazine, *December 1990.*

In this long-term project, you will have the opportunity to decide whether you agree with Dr. Lederberg's statement and what factors have come together to result in the emergence of the disease you are investigating.

ANALYSIS

1. What do you think is meant by a "new or emerging disease"? Where might a "new disease" come from?
2. Describe some of the biological, social, political, and economic issues that might be involved in the emergence or reemergence of a disease.
3. Many social and economic endeavors have unintentionally resulted in the emergence of infectious diseases. For example, in the building of the Aswan dam, an unforeseen result was that it also assisted in epidemics of yellow fever and schistosomiasis. What do you think of this trade-off between agricultural progress and disease occurring in an area? Do you need more information in order to decide? If so, what kind of information will help you? Do you think that projects such as the Aswan Dam should take into consideration the possibilities of infectious disease which might be brought on? Why or why not? What information might be needed to predict such an outbreak?
4. What does Dr. Lederberg mean in saying we will "rue it" if we do not pay attention to the ecological relations between infectious agents, animals, and humans? Do you agree? Why or why not?

EXTENDING IDEAS

Chronic fatigue syndrome (CFS) is a disorder characterized by profound tiredness and weakness; patients with CFS become exhausted after mild physical exertion and are often unable to conduct the routine tasks of life with fatigue. A difficult illness to diagnose since incapacitating fatigue is associated with a wide range of well-defined diseases, CFS was officially given disease status in 1988. Most often occurring in white women between the ages of 25 and 45, the cause of the disease has not been determined. No evidence exists that CFS is communicable through person-to-person contact, or even that it is a communicable disease but several lines of research implicated the possible involvement of several well-characterized viruses. Research CFS, its clinical aspects and demographics and possible causes then decide whether you think it is an infectious disease. Support your decision with evidence from your research.